

1. *The Barometrical Method of measuring the Height of Mountains, with two new Tables shewing the Height of the Atmosphere at given Altitudes of Mercury. Extracted chiefly from the Observations of John James Scheuchzer, M. D. Professor of Mathematicks at Zurich, and a Member of the Imperial, and Royal Societies of London and Prussia. By J. G. Scheuchzer, M. D. F. R. S. & Coll. Med. Lond. Lic.*

THE Height of Mountains, and their Elevation above the Level of the Sea, hath been at all Times thought worthy the Attention of inquisitive Philosophers. We find in *Pliny* \*, that *Dicaearchus*, one of the old Geographers, a Disciple of *Aristotle*, and, as *Pliny* himself styles him, a Man of great Learning, had by particular Order of some Princes measured the Heights of several Mountains, and that the highest of them, *Mount Pelius* in *Thessalia*, was found by his Observations 1250 Paces high perpendicularly. *Cleomedes* also, a *Grecian* Astronomer and Geographer, who lived sometime before our Saviour's Nativity, asserts †, that the highest Mountain cannot be above 15 Stadia, or 9375 *Roman* Feet high.

But *Plutarch* ‡ fixes the perpendicular Height of the highest Mountains, as also the greatest Depth of the Sea, only to 10 Stadia, or 6250 *Roman* Feet. It will appear by the Sequel of this Paper, that the

\* Hist. Nat. L. xi. c. 65. † *Cyclicæ Theor.* Cap. x. ‡ *In vita Aemilij.*

Height of Mountains, as determined by these early Writers, doth not so very much deviate from Truth, as one would be apt to suspect from the infant State of Arts and Sciences in those Times. Particularly the 15 Stadia of *Cleomedes*, which make out 9375 *Roman*, or 10,214 *Paris* Feet, will be found by the following Observations to come very near the Height of the Mountains of *Swisserland*, which, although the highest of *Europe*, do not rise above 10,000 *Paris* Feet above the Level of the Sea; and it may seem surprizing, that subsequent Writers, even such as were otherwise deeply skill'd in mathematical Learning, have run them up to an extravagant, and altogether unnatural Height.

At first, it is not improbable, they went only upon bare Conjectures; but afterwards, when Geometry came to be more and more improved, Quadrants, Semi-circles, and other Geometrical Instruments were call'd in Use, by the Means of which, and by a Trigonometrical Calculation, the Heights of Places could be determined in a more satisfactory Manner. And yet, however true the Principles be, upon which this Method is founded, however nice the Instruments, and however curious the Observer, the Method itself must be owned, and hath been found by undoubted Experiments, to fall far short of that Accuracy, which it seems to promise; and the more considerable the Heights are, the more uncertain it will be. For in the first Place, as the State of the Air is very different in different Seasons and different Weather, its Refraction also becomes thereby greatly altered, which occasions the Tops of Mountains to appear higher at some Times than they do at others, and at all Times higher than they actually are. But besides, there is another In-

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conveniency,

conveniency, which whoever is acquainted with the true State of mountainous Countries, must needs be sensible of, and that is the extream Difficulty of meeting at the Bottom of high Mountains with Plains large enough for a proper horizontal Stand, or Basis, to such a Triangle, as an accurate and knowing Observer would think satisfactory to determine a considerable Height, making even proper Allowances for the Air's Refraction.

Among the many Improvements in Natural Philosophy, which are owing to the Toricellian Tube, one of the most considerable Inventions of the last Century, it hath been thereby enriched with a new Method of measuring the respective Heights of Places, and their Elevation above the Level of the Sea; a Method, which, although it must be owned, that it hath not as yet, and perhaps, considering the Inconstancy of the Air, hardly ever will be brought to an absolute Degree of Certainty, is yet in many Respects preferable to the Trigonometrical one, as it hath also been found by Experience to come nearer the Truth, and leads us, by a new and singular Scale, from the very Horizon of the Sea to the Tops of the highest Mountains, a Distance far beyond the Reach of Geometrical Instruments. This new Method is grounded upon that essential Quality of the Air, its Gravity or Pressure. As the Column of Mercury in the Barometer is counterpoised by a Column of Air of equal Weight, so whatever Causes will make the Air heavier or lighter, its Pressure will be thereby increased, or lessened, and consequently the Mercury rise or fall. Again the Air is more or less condensed, or expanded, in Proportion to the Weight, or Force, which presses it: Hence it is, that

in *England, Holland*, the maritime Provinces of *France*, and in general all those Countries which border upon the Sea, the Mercury stands highest, that the higher you remove from the Sea into the midland Countries, the lower the Mercury will descend, because the Air also becomes more rarefied and lighter, and that upon the Tops of the highest Mountains it falls lowest, and these Heights of the Mercury in different Places are reciprocally, as the Expansions of the Air. From these Principles, supported by a competent Number of Observations, it hath been attempted by several learned Men, to derive proper Tables, whereby the Height of any Place may be determined, if the Height of the Barometer be given, or the Height of the Barometer determined from the given Altitude of the Place, and likewise the Expansions of the Air settled, as they answer to every Inch, or Part of an Inch, in the Barometer.

I pass over the first Experiment of this Kind, which was made in the Year 1648 (but a few Years after the Invention of the Torricellian Tube was made publick in *France* by Father *Mersenne*) by Monsieur *Perier*, according to the Directions of the celebrated Monsieur *Pascal*, his Brother-in-Law, upon the high Mountain *Puy de Domme*, near *Clermont* in *Auvergne*, the Height whereof was thereby determined to 500 *French Toises*, or 3000 *Paris Feet*. (See the Appendix to *M. Pascal's Traité de l'Equilibre des Liqueurs* \*.) Nor will my present Purpose admit a particular Enumeration of those made sometime after, in 1661, 1665, and 1666, by *George Sinclair*, Professor of Philosophy in the University of *Glasgow*, upon the Cathe-

\* *Paris*, 1663, 8vo. pag. 177.

dral of that University, upon several high Mountains in *Scotland*, and likewise in some Wells and Coal-pits, a particular Account whereof he inserted in his *Ars magna gravitatis & levitatis* \*. I will only observe, that these Experiments of *Sinclair*, as well as that of Monsieur *Perier*, were intended not so much to lay the Foundation of a Calculation, whereby to determine the differing Heights of Places, as to prove the Gravity and Pressure of the Air, a Problem very much controverted at that Time, and to shew, that the same is much more considerable in Valleys than at the Top of Mountains, and still greater in Proportion at the Bottom of Wells, Mines, &c.

But this Matter was pursued still farther by the Members of the Royal Academy of Sciences at *Paris*, particularly, when by Order of *Lewis XIV*, they drew that expensive *Meridian* Line across the whole Kingdom of *France*. *M. Mariotte*, a celebrated Member of that Academy, was one of the first that laid down certain Rules for the Construction of such Tables, as might serve to determine both the Elevation of Places above the Level of the Sea from given Altitudes of Mercury, and the Heights of the Air, answering to every Line of Mercury in the Barometer, from 28'', where the Mercury was supposed to stand at a Medium near the Sea. The Principles he went upon, and the Method he followed, he discoursed of at large, in his *Second Essay de la Nature de l'Air*.

Sometime after, in 1686, the ingenious Dr. *Edmund Halley* went about another Calculation, which he derived partly from Principles agreeing with those of

\* Roterodami, 1669, 4to. pag. 129, 132, 134, 144, &c seq.

*M. Mariotte*, partly from the specifick Weight of Air and Mercury, which were found by Experiments to be as 1 to 10,800; Air being to Water as 1 to 800, and Water to Mercury as 1 to  $13 \frac{1}{2}$ , or very near it. If so, as the Column of Mercury in the Barometer is counterpoised by a Column of Air of equal Weight, a Cylinder of Air of 10,800 Inches, or 900 Feet will be equal to one Inch of Mercury, and 90 Feet to  $\frac{1}{10}$  of an Inch, or  $75$  to  $\frac{1}{12}$  Part of it. The Height of the Air, as it answers to one Inch of Mercury, being thus determined, and the Expansions of the Air being reciprocally as the Heights of Mercury, Dr. *Halley*, by the Help of the Hyperbola and its Asymptotes, calculated two Tables, one shewing the Altitude to given Heights of Mercury, the other the Heights of Mercury at given Altitudes. These Tables, the first that ever were calculated, together with the Doctor's whole Method of proceeding, and an ingenious Attempt of his to discover the true Reason of the Rise and Fall of Mercury upon Change of Weather, were printed in the *Philosophical Transactions* \*, and the Tables themselves were very lately re-printed, with some Observations upon them, by Dr. *Desaguliers* †.

In the Year 1703, when the *Meridian* Line, first begun by *M. Picard* in 1669, afterwards continued in 1683, was farther pursued, several Observations of this Kind were made, and the Heights of several considerable Mountains, particularly in the Southern Parts of *France*, determined as well by Trigonometrical as Barometrical Observations. Monsieur *Cassini* the Younger took that Opportunity to compare these Observations

\* N° 181. pag. 106: † Phil. Transact. N° 386.

with

with the Rules laid down by *M. Mariotte* \*, in order to which, and conform to the said Rules, he calculated two Tables, one shewing the Height of the Atmosphere, as it answers to every Line of Mercury in the Barometer, the other determining the Height of the Atmosphere above the Level of the Sea at given Altitudes of Mercury. But having afterwards, upon Comparison, found that the Observations made in 1703, did not in the Main agree with the Rules of *M. Mariotte*, and that the Heights of Places, as they appeared by those Observations, exceeded, generally speaking, the Numbers resulting from the Tables made by him according to the said Rules, he thought it necessary to calculate two new ones, wherein indeed the Results are considerably greater than in the Tables framed according to the Rules of *M. Mariotte*; insomuch, that for Instance, a Place, where the Mercury falls to 22 Inches, rises above the Level of the Sea, according to *Mariotte*, 852 Toises, or 5112 Paris Feet; and, according to *Cassini*, 1158 Toises, or 6948 Feet, which makes a Difference of 1836 Paris Feet, or 306 Toises. Dr. *Desaguliers*, in his Dissertation concerning the Figure of the Earth †, hath already shewn how far the Observations made by the Gentlemen, that drew the *Meridian* across the Kingdom of *France*, differ from each other; insomuch, that there are not two in nine, where the Number of Toises, said to correspond to the Heights of the Barometer, agree together; and that consequently the Heights of Mountains, as determined by these Observations, are little to be depended on.

\* Memoires de l' Acad. Royale, 1705. pag. 61. & seq.      † Phil. Trans.  
N<sup>o</sup> 386. pag. 211.

My Father, Dr. *J. J. Scheuchzer*, in his Journeys over the Mountains of *Switzerland*, as they were more particularly calculated for the Improvement of Natural Philosophy in its several Branches, neglected no Opportunity, along with his other Observations, to make such Experiments with the Barometer, as might serve to illustrate the Qualities of the Air, to settle the respective Heights of Places, and particularly to shew, how much our Mountains rise, as well above the Level of the Sea, as above other neighbouring Mountains in *France, Italy, Spain, &c.* Many of these Observations are scattered up and down in his Writings, particularly his *Itinera Alpina*, and the several Parts of his *Natural History of Switzerland*, which last Work was published in *High German*. It would be too tedious to mention all the Experiments he made at different Times, and upon different Mountains. But my Design in this Paper requires me to be particular in one, which for the Height measured both with the Line and Barometer is, I believe, the most considerable that ever was made, and which enabled him more particularly to examine the two Tables made by *Cassini* the Younger, according to the Rules of Mr. *Mariotte*, and the Observations made by him and others, when the *Meridian* Line was perfected in 1703.

This curious Experiment was made in the Year 1709, at *Pfeffers*, a celebrated Mineral Water in the County of *Sargans*, at the Bottom and Top of a Mountain, which rises from a small Brook, called the *Taminna*, to the Height of 714 *Paris* Feet, as appeared by letting a Line drop down perpendicularly from a Tree at Top full to the Bottom. At the Bottom of this Mountain, near the *Taminna*, the Mercury was by repeated Experiments

periments observed at  $25''$ ,  $9\frac{1}{2}'''$ , and at the Top it descended to  $24''$ ,  $11\frac{1}{2}'''$ , so that it fell just 10 Lines, for 714 Feet, which gives about 71 *Paris* Feet for a Line, if the Heights answering to every Line were supposed to be equal.

I must here once for all desire the Reader to take Notice, that I have made use in this Paper of *Paris* Measure, namely, of Toises ( $^{\circ}$ ) Feet ( $'$ ) Inches ( $''$ ) and Lines ( $'''$ ). Every Toise is reckoned at six Foot, the Foot is divided into twelve Inches, and the Inch into twelve Lines.

The Heights of the Barometer at the Bottom and Top of the Mountain being thus given, the Height of it should be, according to *M. Mariotte*,  $116^{\circ}$ ,  $0'$ ,  $8''$ ,  $11'''$ , or 696 *Paris* Feet,  $8''$ ,  $11'''$ , which falls  $17'$ ,  $3''$ ,  $1'''$ , short of the true Height, and according to *Cassini*  $153^{\circ}$   $3'$ ,  $8''$ , that is, 921 *Paris* Feet,  $8''$ , which exceeds the true Height by 207 *Paris* Feet, 8 Inches; whereby it appears, that the Table made according to the Rules of *Mariotte* is much preferable to that of *Cassini* the Younger. The same was likewise confirmed by another Experiment made in *June* 1715, upon the Steeple of our Cathedral at *Zurich*. At the Foot of the Steeple the Barometer stood at  $26''$ ,  $10'''$ , and at the Top at  $26''$ ,  $7\frac{1}{2}'''$ , and the Height of the Steeple was found by the Line of 241 *Paris* Feet, 4 Inches, which gives very near 69 *Paris* Feet for one Line. According to the Table of *Mariotte*, the Height of the Steeple should have been of 237 *Paris* Feet, according to *Cassini*, 265, and according to the new Calculation (of which by and by) made pursuant to the Experiments above, it comes to  $243^{\circ}$ ,  $16''$ ,  $2'''$ , or about two Foot more than the true Height.

It appearing by the Experiments made at *Pfeffers*, that from  $25''$ ,  $9\frac{1}{3}'''$  the Barometer descends to  $24''$ ,  $11\frac{1}{3}'''$ , that is, just 10 Lines, for the Height of 714 Feet, and the Expansions of the Air being reciprocally as the Heights of Mercury, my Uncle, Dr. *John Schenbzer*, undertook, pursuant to these Principles, and the Properties of the Hyperbola, to calculate a new Table, after the following Method.

|                                                                                                                                                                                                                              |                                                                                                                                                                                              |                                                                                                                        |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|
| As the Difference Is to Foot,<br>of the Logarithms<br>of the two given<br>Heights of the Ba-<br>rometer $25''$ $9\frac{1}{3}'''$<br>and $24''$ $11\frac{1}{3}'''$ , that<br>is $309\frac{1}{3}$ and $299\frac{1}{3}$ ,<br>or | So the Difference<br>of the Logarithms<br>of the Height of<br>Mercury near the<br>Sea, $28''$ $1'''$ to<br>any lesser Height,<br>as for Instance $28''$<br>$0'''$ , that is 337<br>— 336, or | To the Height of<br>the Atmosphere<br>above the Level<br>of the Sea, as it<br>answers to one<br>Line of Mercury,<br>is |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|

928 — 898

142717

714

1011 — 1008

12906

 $64'$ ,  $6''$ ,  $9'''$ 

Thus the Height of the Atmosphere at  $28''$  appears to be of  $10^{\circ}$ ,  $4'$ ,  $6''$ ,  $9'''$ , but, according to *Mariotte*, it is only of  $10^{\circ}$ ,  $3'$ , or 63 Feet, and *Cassini* supposes it only at  $10^{\circ}$ , or 60 Foot.

In like Manner the Height of the Atmosphere, from  $28''$ ,  $0'''$ , to  $27''$ ,  $11'''$  is found to be  $64'$ ,  $9''$ ,  $2'''$ . According to the same Rule half the Height of the Atmosphere, that is, the Height of the Place, where the Mercury in the Barometer would descend to 14 Inches, appears to be,  $15060'$ ,  $3''$ ,  $0'''$ , or  $2510^{\circ}$ ,  $0'$ ,  $3''$ ,  $0'''$ . Still upon the same Principle the Mercury will descend to one Line at the Height of 133,397 *Paris* Feet above the Level of the Sea, which make 22,232 Toises, 5 Feet,

5 Feet, or 11 *Paris* Miles (at 2000 Toises the Mile) 232 Toises, 5 Foot. But as in order to determine the whole Height of the Atmosphere, the Logarithm of 1<sup>'''</sup> ought to be deducted from the Logarithm of 336<sup>'''</sup> or 28<sup>''</sup> 0<sup>'''</sup>, and as that Logarithm is 00000, it follows from thence, that beyond the Place, where the Mercury would descend to 1<sup>'''</sup>, the Air is expanded into an Indefinite Space.

For the Satisfaction of the Curious, I have added the Tables themselves, to wit, those which *Cassini* the Younger calculated according to the Rules of *Mariotte*, those which he deduced from the Observations made by the Gentlemen of the Royal Academy of Sciences, who drew the *Meridian* Line, and those which my Uncle calculated from the Observation made at *Pfeffers* in 1709.

In another Paper on this Subject I intend to compare the Height of Mountains, as determined by divers antient and modern Writers, with the true Height of them, as it appears to be by the Barometrical Observations, particularly those made by my Father on the high Mountains of *Swisserland*.

## II. *Observations of a Difference of Sex in Mistleto, in a Letter from the Reverend Mr. Edmund Barrel to Sir Hans Sloane, Bart. &c.*

*S I R,*

**A**FTER I had mentioned my being pretty well assured, that the Plants of Mistleto were some of them Male, and some Female; and had promised to

# T A B L E S of the Height of the A T M O S P H E R E to given Altitudes of *Mercury*.

| The Fall of <i>Mercury</i> in the Barometer |     | The Height of the Atmosphere, as it answers to every Line in the Barometer, according to <i>Mariotte</i> . |   |    |     | According to <i>Cassini</i> . |   |    |   | According to Dr. <i>Schenckzer</i> . |    |    |     | The Height of the Atmosphere above the Level of the Sea, according to <i>Mariotte</i> . |   |       |       | According to <i>Cassini</i> . |    | According to Dr. <i>Schenckzer</i> . |   |    |     | Height of the Mercury in the Barometer. |     |
|---------------------------------------------|-----|------------------------------------------------------------------------------------------------------------|---|----|-----|-------------------------------|---|----|---|--------------------------------------|----|----|-----|-----------------------------------------------------------------------------------------|---|-------|-------|-------------------------------|----|--------------------------------------|---|----|-----|-----------------------------------------|-----|
| II                                          | III | 0                                                                                                          | I | II | III | 0                             | I | 0  | I | 0                                    | I  | II | III | 0                                                                                       | I | II    | III   | I                             | II | 0                                    | I | II | III | II                                      | III |
| 0                                           | 0   | 10                                                                                                         | 3 | 0  | 0   | 10                            | 0 | 10 | 4 | 6                                    | 9  |    |     | 0                                                                                       | 0 | 0     | 0     | 0                             | 0  | 0                                    | 0 | 0  | 0   | 28                                      | 0   |
| 1                                           |     | 10                                                                                                         | 3 | 2  | 3   | 10                            | 1 | 10 | 4 | 9                                    | 2  |    |     | 10                                                                                      | 3 | 2     | 3     | 10                            | 1  | 10                                   | 4 | 9  | 2   | —                                       | 11  |
| 2                                           |     | 10                                                                                                         | 3 | 4  | 6   | 10                            | 2 | 10 | 4 | 11                                   | 5  |    |     | 21                                                                                      | 0 | 6     | 9     | 20                            | 3  | 21                                   | 3 | 8  | 7   | —                                       | 10  |
| 3                                           |     | 10                                                                                                         | 3 | 6  | 10  | 10                            | 3 | 10 | 5 | 1                                    | 1  |    |     | 31                                                                                      | 4 | 1     | 7     | 31                            | 0  | 32                                   | 2 | 9  | 8   | —                                       | 9   |
| 4                                           |     | 10                                                                                                         | 3 | 9  | 1   | 10                            | 4 | 10 | 5 | 4                                    | 1  |    |     | 42                                                                                      | 1 | 10    | 8     | 41                            | 4  | 43                                   | 2 | 1  | 9   | —                                       | 8   |
| 5                                           |     | 10                                                                                                         | 3 | 11 | 4   | 10                            | 5 | 10 | 5 | 6                                    | 6  |    |     | 52                                                                                      | 5 | 10    | 0     | 52                            | 3  | 54                                   | 1 | 8  | 3   | —                                       | 7   |
| 6                                           |     | 10                                                                                                         | 4 | 1  | 9   | 11                            | 0 | 10 | 5 | 8                                    | 11 |    |     | 63                                                                                      | 3 | 11    | 9     | 63                            | 3  | 65                                   | 1 | 5  | 2   | —                                       | 6   |
| 7                                           |     | 10                                                                                                         | 4 | 4  | 1   | 11                            | 1 | 10 | 5 | 11                                   | 3  |    |     | 74                                                                                      | 2 | 3     | 10    | 74                            | 4  | 76                                   | 1 | 4  | 5   | —                                       | 5   |
| 8                                           |     | 10                                                                                                         | 4 | 6  | 5   | 11                            | 2 | 10 | 0 | 1                                    | 8  |    |     | 85                                                                                      | 0 | 10    | 3     | 86                            | 0  | 87                                   | 1 | 6  | 1   | —                                       | 4   |
| 9                                           |     | 10                                                                                                         | 4 | 8  | 10  | 11                            | 3 | 11 | 0 | 4                                    | 1  |    |     | 95                                                                                      | 5 | 7     | 1     | 97                            | 3  | 98                                   | 1 | 10 | 2   | —                                       | 3   |
| 10                                          |     | 10                                                                                                         | 4 | 11 | 2   | 11                            | 4 | 11 | 0 | 6                                    | 6  |    |     | 106                                                                                     | 4 | 6     | 3     | 109                           | 1  | 109                                  | 2 | 4  | 8   | —                                       | 2   |
| 11                                          |     | 10                                                                                                         | 5 | 1  | 7   | 11                            | 5 | 11 | 0 | 8                                    | 11 |    |     | 117                                                                                     | 3 | 7     | 10    | 121                           | 0  | 120                                  | 3 | 1  | 7   | —                                       | 1   |
| I                                           | 0   | 10                                                                                                         | 5 | 4  | 0   | 12                            | 0 | 11 | 0 | 11                                   | 4  |    |     | 128                                                                                     | 2 | 11    | 10    | 133                           | 0  | 131                                  | 4 | 0  | 11  | 27                                      | 0   |
| 1                                           |     | 10                                                                                                         | 5 | 6  | 5   | 12                            | 1 | 11 | 1 | 1                                    | 10 |    |     | 139                                                                                     | 2 | 6     | 3     | 145                           | 1  | 142                                  | 5 | 2  | 9   | —                                       | 11  |
| 2                                           |     | 10                                                                                                         | 5 | 8  | 10  | 12                            | 2 | 11 | 1 | 4                                    | 4  |    |     | 150                                                                                     | 2 | 3 1/2 | 3 1/2 | 157                           | 3  | 154                                  | 0 | 7  | 1   | —                                       | 10  |
| 3                                           |     | 10                                                                                                         | 5 | 11 | 1   | 12                            | 3 | 11 | 1 | 6                                    | 10 |    |     | 161                                                                                     | 2 | 2     | 5     | 170                           | 0  | 165                                  | 2 | 1  | 11  | —                                       | 9   |
| 4                                           |     | 11                                                                                                         | 0 | 1  | 9   | 12                            | 4 | 11 | 1 | 9                                    | 5  |    |     | 172                                                                                     | 2 | 4     | 2     | 182                           | 4  | 176                                  | 3 | 11 | 4   | —                                       | 8   |
| 5                                           |     | 11                                                                                                         | 0 | 4  | 3   | 12                            | 5 | 11 | 2 | 0                                    | 0  |    |     | 183                                                                                     | 2 | 8     | 5     | 195                           | 3  | 187                                  | 5 | 11 | 4   | —                                       | 7   |
| 6                                           |     | 11                                                                                                         | 0 | 6  | 9   | 13                            | 0 | 11 | 2 | 2                                    | 7  |    |     | 194                                                                                     | 3 | 3     | 2     | 208                           | 3  | 199                                  | 2 | 1  | 11  | —                                       | 6   |
| 7                                           |     | 11                                                                                                         | 0 | 9  | 3   | 13                            | 1 | 11 | 2 | 5                                    | 2  |    |     | 205                                                                                     | 4 | 0     | 5     | 221                           | 4  | 210                                  | 4 | 7  | 1   | —                                       | 5   |
| 8                                           |     | 11                                                                                                         | 0 | 11 | 10  | 13                            | 2 | 11 | 2 | 7                                    | 9  |    |     | 216                                                                                     | 5 | 0     | 3     | 235                           | 0  | 221                                  | 1 | 2  | 10  | —                                       | 4   |
| 9                                           |     | 11                                                                                                         | 1 | 2  | 4   | 13                            | 3 | 11 | 2 | 10                                   | 4  |    |     | 228                                                                                     | 0 | 2     | 7     | 248                           | 3  | 233                                  | 4 | 2  | 2   | —                                       | 3   |
| 10                                          |     | 11                                                                                                         | 1 | 4  | 11  | 13                            | 4 | 11 | 3 | 1                                    | 0  |    |     | 239                                                                                     | 1 | 7     | 6     | 262                           | 1  | 245                                  | 1 | 3  | 2   | —                                       | 2   |
| 11                                          |     | 11                                                                                                         | 1 | 7  | 7   | 13                            | 5 | 11 | 3 | 6                                    | 4  |    |     | 250                                                                                     | 3 | 3     | 1     | 276                           | 0  | 256                                  | 4 | 9  | 6   | —                                       | 1   |
| 2                                           | 0   | 11                                                                                                         | 1 | 10 | 2   | 14                            | 0 | 11 | 3 | 9                                    | 0  |    |     | 261                                                                                     | 5 | 1     | 3     | 290                           | 0  | 268                                  | 2 | 6  | 6   | 26"                                     | 0   |
| 1                                           |     | 11                                                                                                         | 2 | 0  | 9   | 14                            | 1 | 11 | 3 | 11                                   | 8  |    |     | 273                                                                                     | 1 | 2     | 0     | 304                           | 1  | 280                                  | 0 | 6  | 2   | —                                       | 11  |
| 2                                           |     | 11                                                                                                         | 2 | 3  | 4   | 14                            | 2 | 11 | 4 | 2                                    | 4  |    |     | 284                                                                                     | 3 | 5     | 4     | 318                           | 3  | 291                                  | 4 | 8  | 6   | —                                       | 10  |
| 3                                           |     | 11                                                                                                         | 2 | 6  | 0   | 14                            | 3 | 11 | 4 | 5                                    | 0  |    |     | 295                                                                                     | 5 | 11    | 4     | 333                           | 0  | 303                                  | 3 | 1  | 6   | —                                       | 9   |
| 4                                           |     | 11                                                                                                         | 2 | 8  | 8   | 14                            | 4 | 11 | 4 | 7                                    | 8  |    |     | 307                                                                                     | 2 | 8     | 0     | 347                           | 4  | 315                                  | 1 | 9  | 2   | —                                       | 8   |
| 5                                           |     | 11                                                                                                         | 2 | 11 | 4   | 14                            | 5 | 11 | 4 | 10                                   | 4  |    |     | 318                                                                                     | 5 | 7     | 4     | 362                           | 3  | 327                                  | 0 | 7  | 6   | —                                       | 7   |
| 6                                           |     | 11                                                                                                         | 3 | 2  | 1   | 15                            | 0 | 11 | 5 | 1                                    | 0  |    |     | 330                                                                                     | 2 | 9     | 5     | 377                           | 3  | 338                                  | 5 | 8  | 6   | —                                       | 6   |
| 7                                           |     | 11                                                                                                         | 3 | 4  | 10  | 15                            | 1 | 11 | 5 | 3                                    | 9  |    |     | 342                                                                                     | 0 | 2     | 3     | 392                           | 4  | 350                                  | 5 | 0  | 5   | —                                       | 5   |
| 8                                           |     | 11                                                                                                         | 3 | 7  | 7   | 15                            | 2 | 11 | 5 | 6                                    | 7  |    |     | 353                                                                                     | 3 | 9     | 10    | 408                           | 0  | 362                                  | 4 | 7  | 0   | —                                       | 4   |
| 9                                           |     | 11                                                                                                         | 3 | 10 | 4   | 15                            | 3 | 11 | 5 | 9                                    | 5  |    |     | 365                                                                                     | 1 | 8     | 2     | 423                           | 3  | 374                                  | 4 | 4  | 5   | —                                       | 3   |
| 10                                          |     | 11                                                                                                         | 4 | 1  | 1   | 15                            | 4 | 12 | 0 | 0                                    | 5  |    |     | 376                                                                                     | 5 | 9     | 3     | 439                           | 1  | 386                                  | 4 | 4  | 10  | —                                       | 2   |
| 11                                          |     | 11                                                                                                         | 4 | 3  | 11  | 15                            | 5 | 12 | 0 | 3                                    | 5  |    |     | 388                                                                                     | 4 | 1     | 2     | 455                           | 0  | 398                                  | 4 | 8  | 3   | —                                       | 1   |
| 3                                           | 0   | 11                                                                                                         | 4 | 6  | 9   | 16                            | 0 | 12 | 0 | 6                                    | 6  |    |     | 400                                                                                     | 2 | 7     | 11    | 471                           | 0  | 410                                  | 5 | 2  | 9   | 25                                      | 0   |
| 1                                           |     | 11                                                                                                         | 4 | 9  | 6   | 16                            | 1 | 12 | 0 | 9                                    | 8  |    |     | 412                                                                                     | 1 | 5     | 5     | 487                           | 1  | 423                                  | 0 | 0  | 5   | —                                       | 11  |
| 2                                           |     | 11                                                                                                         | 5 | 0  | 4   | 16                            | 2 | 12 | 1 | 0                                    | 10 |    |     | 424                                                                                     | 0 | 5     | 9     | 503                           | 3  | 435                                  | 1 | 1  | 3   | —                                       | 10  |
| 3                                           |     | 11                                                                                                         | 5 | 3  | 3   | 16                            | 3 | 12 | 1 | 4                                    | 0  |    |     | 435                                                                                     | 5 | 9     | 0     | 520                           | 0  | 447                                  | 2 | 5  | 3   | —                                       | 9   |
| 4                                           |     | 11                                                                                                         | 5 | 6  | 2   | 16                            | 4 | 12 | 1 | 7                                    | 2  |    |     | 447                                                                                     | 5 | 3     | 2     | 536                           | 4  | 459                                  | 4 | 0  | 5   | —                                       | 8   |
| 5                                           |     | 11                                                                                                         | 5 | 9  | 1   | 16                            | 5 | 12 | 1 | 10                                   | 4  |    |     | 459                                                                                     | 5 | 0     | 3     | 553                           | 3  | 471                                  | 5 | 10 | 9   | —                                       | 7   |
| 6                                           |     | 12                                                                                                         | 0 | 0  | 0   | 17                            | 0 | 12 | 2 | 1                                    | 6  |    |     | 471                                                                                     | 5 | 0     | 3     | 570                           | 3  | 484                                  | 2 | 0  | 3   | —                                       | 6   |
| 7                                           |     | 12                                                                                                         | 0 | 2  | 11  | 17                            | 1 | 12 | 2 | 4                                    | 8  |    |     | 483                                                                                     | 5 | 3     | 2     | 587                           | 4  | 496                                  | 4 | 4  | 11  | —                                       | 5   |
| 8                                           |     | 12                                                                                                         | 0 | 5  | 11  | 17                            | 2 | 12 | 2 | 8                                    | 0  |    |     | 495                                                                                     | 5 | 9     | 1     | 605                           | 0  | 509                                  | 1 | 0  | 11  | —                                       | 4   |
| 9                                           |     | 12                                                                                                         | 0 | 8  | 11  | 17                            | 3 | 12 | 2 | 11                                   | 2  |    |     | 508                                                                                     | 0 | 6     | 0     | 622                           | 3  | 521                                  | 4 | 0  | 1   | —                                       | 3   |
| 10                                          |     | 12                                                                                                         | 0 | 11 | 11  | 17                            | 4 | 12 | 3 | 2                                    | 4  |    |     | 520                                                                                     | 1 | 5     | 11    | 640                           | 1  | 534                                  | 1 | 2  | 5   | —                                       | 2   |
| 11                                          |     | 12                                                                                                         | 1 | 2  | 11  | 17                            | 5 | 12 | 3 | 5                                    | 8  |    |     | 532                                                                                     | 2 | 8     | 10    | 658                           | 0  | 546                                  | 4 | 8  | 1   | —                                       | 1   |
| 4                                           | 0   | 12                                                                                                         | 1 | 6  | 0   | 18                            | 0 | 12 | 3 | 8                                    | 10 |    |     | 544                                                                                     | 2 | 3     | 10    | 676                           | 0  | 559                                  | 2 | 4  | 11  | 24                                      | 0   |
| 1                                           |     | 12                                                                                                         | 1 | 9  | 1   | 18                            | 1 | 12 | 4 | 0                                    | 0  |    |     | 556                                                                                     | 5 | 11    | 11    | 694                           | 1  | 572                                  | 0 | 4  | 11  | —                                       | 11  |
| 2                                           |     | 12                                                                                                         | 2 | 0  | 2   | 18                            | 2 | 12 | 4 | 3                                    | 2  |    |     | 569                                                                                     | 2 | 0     | 1     | 712                           | 3  | 584                                  | 4 | 8  | 1   | —                                       | 10  |
| 3                                           |     | 12                                                                                                         | 2 | 3  | 3   | 18                            | 3 | 12 | 4 | 6                                    | 4  |    |     | 581                                                                                     | 4 | 3     | 4     | 731                           | 0  | 597                                  | 3 | 2  | 5   | —                                       | 9   |
| 4                                           |     | 12                                                                                                         | 2 | 6  | 5   | 18                            | 4 | 12 | 4 | 9                                    | 6  |    |     | 594                                                                                     | 0 | 9     | 9     | 749                           | 4  | 610                                  | 1 | 11 | 11  | —                                       | 8   |
| 5                                           |     | 12                                                                                                         | 2 | 9  | 7   | 18                            | 5 | 12 | 5 | 0                                    | 8  |    |     | 606                                                                                     | 3 | 7     | 4     | 768                           | 3  | 623                                  | 1 | 0  | 7   | —                                       | 7   |
| 6                                           |     | 12                                                                                                         | 3 | 0  | 9   | 19                            | 0 | 12 | 5 | 3                                    | 10 |    |     | 619                                                                                     | 0 | 1     | 1     | 787                           | 3  | 636                                  | 0 | 4  | 5   | —                                       | 6   |
| 7                                           |     | 12                                                                                                         | 3 | 3  | 11  | 19                            | 1 | 12 | 5 | 7                                    | 0  |    |     | 631                                                                                     | 4 | 0     | 0     | 806                           | 4  | 648                                  | 5 | 11 | 5   | —                                       | 5   |

|    |            |      |            |
|----|------------|------|------------|
| 4  | 12 2 9 7   | 18 5 | 12 5 0 8   |
| 5  | 12 3 0 9   | 19 0 | 12 5 3 10  |
| 6  | 12 3 3 11  | 19 1 | 12 5 7 0   |
| 7  | 12 3 7 2   | 19 2 | 12 5 10 2  |
| 8  | 12 3 10 5  | 19 3 | 13 0 1 4   |
| 9  | 12 4 1 9   | 19 4 | 13 0 4 6   |
| 10 | 12 4 5 0   | 19 5 | 13 0 7 8   |
| 11 | 12 4 8 4   | 20 0 | 13 0 10 10 |
| 5  | 12 4 11 8  | 20 1 | 13 1 2 3   |
| 1  | 12 5 3 0   | 20 2 | 13 1 5 8   |
| 2  | 12 5 6 5   | 20 3 | 13 1 9 1   |
| 3  | 12 5 9 10  | 20 4 | 13 2 0 6   |
| 4  | 13 0 1 4   | 20 5 | 13 2 4 2   |
| 5  | 13 0 4 9   | 21 0 | 13 2 7 10  |
| 6  | 13 0 8 3   | 21 1 | 13 2 10 6  |
| 7  | 13 0 11 10 | 21 2 | 13 3 3 2   |
| 8  | 13 1 3 4   | 21 3 | 13 3 6 10  |
| 9  | 13 1 6 11  | 21 4 | 13 3 10 6  |
| 10 | 13 1 10 6  | 21 5 | 13 4 2 2   |
| 11 | 13 2 2 2   | 22 0 | 13 4 5 10  |
| 6  | 13 2 5 10  | 22 1 | 13 4 9 6   |
| 1  | 13 2 9 6   | 22 2 | 13 5 1 2   |
| 2  | 13 3 1 3   | 22 3 | 13 5 4 10  |
| 3  | 13 3 5 2   | 22 4 | 13 5 8 6   |
| 4  | 13 3 8 9   | 22 5 | 14 0 0 2   |
| 5  | 13 4 0 7   | 23 0 | 14 0 4 2   |
| 6  | 13 4 4 5   | 23 1 | 14 0 8 3   |
| 7  | 13 4 8 3   | 23 2 | 14 1 0 4   |
| 8  | 13 5 0 1   | 23 3 | 14 1 4 5   |
| 9  | 13 5 4 0   | 23 4 | 14 1 8 6   |
| 10 | 13 5 8 0   | 23 5 | 14 2 0 7   |
| 11 | 14 0 0 0   | 24 0 | 14 2 4 8   |
| 7  | 14 0 4 0   | 24 1 | 14 2 8 9   |
| 1  | 14 0 8 0   | 24 2 | 14 3 0 10  |
| 2  |            |      |            |

|            |        |             |      |
|------------|--------|-------------|------|
| 606 3 7 4  | 768 3  | 623 1 0 7   | — 7  |
| 619 0 1 1  | 787 3  | 636 0 4 5   | — 6  |
| 631 4 0 0  | 806 4  | 648 5 11 5  | — 5  |
| 644 1 7 2  | 826 0  | 661 5 9 7   | — 4  |
| 656 5 5 7  | 845 3  | 674 5 10 11 | — 3  |
| 669 3 7 4  | 865 1  | 688 0 3 5   | — 2  |
| 682 2 0 4  | 885 0  | 701 0 11 1  | — 1  |
| 695 0 8 8  | 905 0  | 714 1 9 11  | 23 0 |
| 707 5 8 4  | 925 1  | 727 3 0 2   | — 11 |
| 720 4 11 4 | 945 3  | 740 4 5 10  | — 10 |
| 733 4 3 9  | 966 0  | 754 0 2 11  | — 9  |
| 746 4 3 7  | 986 4  | 767 2 3 5   | — 8  |
| 759 4 4 11 | 1007 3 | 780 4 7 7   | — 7  |
| 772 4 9 8  | 1028 3 | 794 1 3 5   | — 6  |
| 785 5 5 11 | 1049 4 | 807 4 1 11  | — 5  |
| 799 0 5 9  | 1071 0 | 821 1 5 1   | — 4  |
| 812 1 9 5  | 1092 3 | 834 4 11 11 | — 3  |
| 825 3 4 0  | 1114 1 | 848 2 10 5  | — 2  |
| 836 5 2 6  | 1136 0 | 862 1 0 7   | — 1  |
| 852 1 4 8  | 1158 0 | 875 5 6 5   | 22 0 |
| 865 3 10 0 | 1180 1 | 889 4 4 11  | — 11 |
| 879 0 8 0  | 1202 3 | 903 3 6 1   | — 10 |
| 892 3 9 3  | 1225 0 | 917 2 10 11 | — 9  |
| 906 1 2 5  | 1247 4 | 931 2 7 5   | — 8  |
| 919 4 11 2 | 1270 3 | 945 2 7 7   | — 7  |
| 932 2 11 9 | 1293 3 | 959 2 11 9  | — 6  |
| 947 1 4 2  | 1316 4 | 973 3 8 0   | — 5  |
| 961 0 0 5  | 1340 0 | 987 4 8 4   | — 4  |
| 974 5 0 6  | 1363 3 | 1002 0 0 9  | — 3  |
| 988 4 4 6  | 1387 1 | 1016 1 9 3  | — 2  |
| 1002 4 0 6 | 1411 0 | 1030 3 9 10 | — 1  |
| 1016 4 0 6 | 1435 0 | 1044 0 2 6  | 21 0 |
| 1030 4 4 6 | 1459 1 | 1058 2 11 3 | — 11 |
| 1044 5 0 6 | 1483 3 | 1073 0 0 1  | — 10 |

TABLE 3. Height of the  $\beta$ -Transition in  $^{13}\text{C}$  Enriched States of Mercury[illegible][illegible]